Space Weather Technical Forecast

Issued on Thursday, 11 May 2023 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor/Moderate geomagnetic storm conditions expected on Days 1 and 2 (11-12 May), with a chance of G3/Strong storms as Earth sees an expected CME arrival. S1/Minor Solar Radiation Storm easing. Further R1/R2 Minor/Moderate radio blackouts expected.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with an M2.2 flare observed at 10/1421UTC, originating from AR3296 (Eki/Beta-Gamma) and a M2.1 flare observed at 11/0901UTC from AR3294 (Cso/Beta). There are currently nine sunspot regions on the visible disc. AR3296 (Ekc/Beta-Gamma) in the northwest remains the most notable sunspot group although any clear delta spot has now faded in the intermediate portion, producing several M-class flares over recent days. This region was the source of the M4.2 flare late on the 9th May, which subsequently produced a large full halo CME observed in SOHO/LASCO coronagraph imagery. This has been analysed and is Earth-directed, with a likely arrival on Day 1 (11 May), probably late in the day. No other significant Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind, as recorded by ACE at L1, have been at Elevated to Strong levels, steadily reducing from a peak speed of around 680km/s observed at 10/1310UTC, as Earth experienced declining effects of the CME which arrived late on the 09 May. The solar wind density was at average to below average values. The IMF started the period Moderate, with a peak of 11nT observed at 10/1220UTC, gradually declining to the current weak levels around 6nT. The north-south component varied weakly between +5nT/-4nT. The resultant geomagnetic activity was generally Quiet to Unsettled (Kp2-3), but with a G1/Minor Storm (Kp5) interval observed at 10/1200-1500UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16, declined below the S1 threshold over the past 24 hours, with a peak of 83pfu at 10/1250UTC and a steady decline, falling below threshold at 11/0400UTC. High energy electron flux (greater than 2MeV), as measured at GOES16, has been at Background to Moderate levels. The 24-hour integrated fluence has been well below Active levels. At 11/0000UTC 6.7e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High solar activity is likely to continue, with further M-flares likely and a slight chance of isolated X-class flares, mostly from AR3296 or AR3297 in the northwest, as they both continue to rotate closer to the western limb in the coming days.

Solar Wind / Geomagnetic Activity: A full halo CME and shock was observed in coronagraph imagery late on the 09 May, which was associated with an M4.2 flare originating from AR3296 in the northwest quadrant. The CME has been analysed and modelled, which suggests a direct hit to Earth on Day 1 (11 May), most likely arriving later in the day (1500-2100 UTC), although there

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remains some uncertainty. CME effects expected to continue into Day 2, gradually easing into Day 3. Some slight peripheral influence is also possible throughout from several small positive coronal holes, this most likely into Day 4 (14 May), though CME effects expected to dominate.

Geomagnetic activity is expected to be Quiet initially, before increasing to Unsettled or Active (Kp3-4) levels with the expected arrival of the CME from the 09 May. G1-G2/Minor-Moderate Storms (Kp5-6) expected late on Day 1 (11 May) and into Day 2 (12 May), with G3/Strong Storm (Kp7) intervals now viewed as an increased chance. Into Days 3 and 4 (13-14 May) geomagnetic activity expected to reduce to Quiet to Unsettled levels (Kp2-3) pending any further CME influence, with Active intervals (Kp4) likely and a reducing chance of G1-G2/Minor-Moderate Storms (Kp5-6).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux gradually declining to background levels - unless any further significant flares occur, particularly from AR3296 as it nears the western limb in the coming days. Protons may also see enhancement due to the onset of the CME from the 9th May, although this is uncertain. High energy (greater than 2MeV) electron flux is expected to persist at normal background to moderate levels, with a possibility of reaching diurnally high levels on 11 May ahead of the anticipated CME arrival late on 11 May. The associated 24-hour fluence is forecast to persist below the Active threshold.

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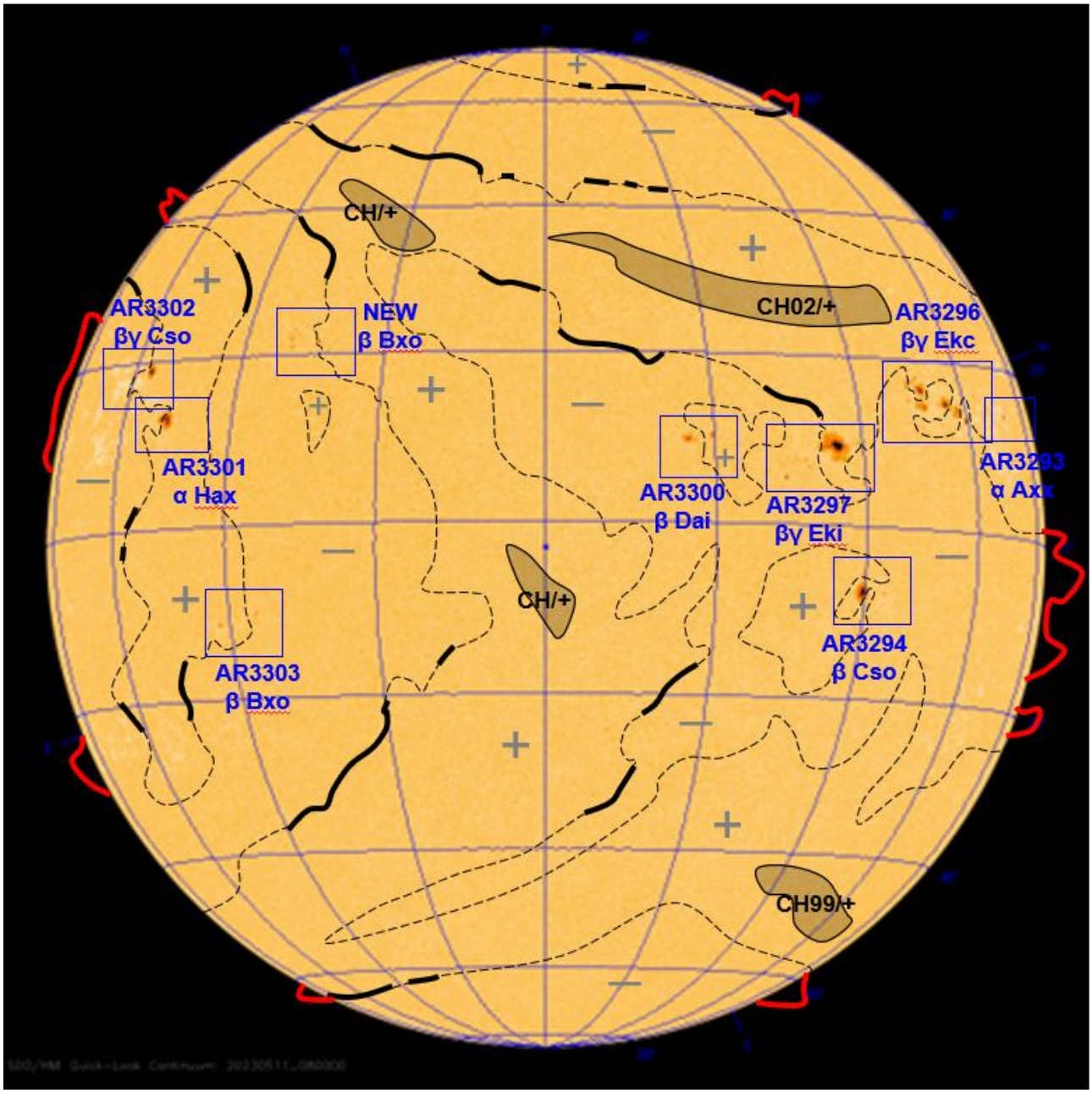
Figure 1. Solar Analysis Valid 11/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A full halo CME and shock was observed in coronagraph imagery late on the 09 May, which was associated with an M4.2 flare originating from AR3296 in the northwest quadrant. The CME has been analysed and modelled, which suggests a direct hit to Earth on Day 1 (11 May), most likely arriving later in the day (1500-2100 UTC), although there remains some uncertainty. CME effects expected to continue into Day 2, gradually easing into Day 3. Some slight peripheral influence is also possible throughout from several small positive coronal holes, this most likely into Day 4 (14 May), though CME effects expected to dominate.

Geomagnetic activity is expected to be Quiet initially, before increasing to Unsettled or Active (Kp3-4) levels with the expected arrival of the CME from the 09 May. G1-G2/Minor-Moderate Storms (Kp5-6) expected late on Day 1 (11 May) and into Day 2 (12 May), with G3/Strong Storm (Kp7) intervals now viewed as an increased chance.

Into Days 3 and 4 (13-14 May) expected to reduce to Quiet to Unsettled levels (Kp2-3) pending any further CME influence, with Active intervals (Kp4) likely and a reducing chance of G1-G2/Minor-Moderate Storms (Kp5-6).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	90	80	20	10
Strong	G3	No	50	30	5	1
Severe	G4	No	15	10	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2100	Full	AR3296	NW	1450 km/s	11/1800 UTC	Associated with M4/2 flare from AR3296. Shock expected

Figure 2: Latest MOSWOC ENLIL output (top) shows CME arriving on Day 1 (11 May) although considered likely too fast and CME expected to arrive later in the day – around 1800 UTC – although with some uncertainty, which can be seen in the ensemble spread (bottom).

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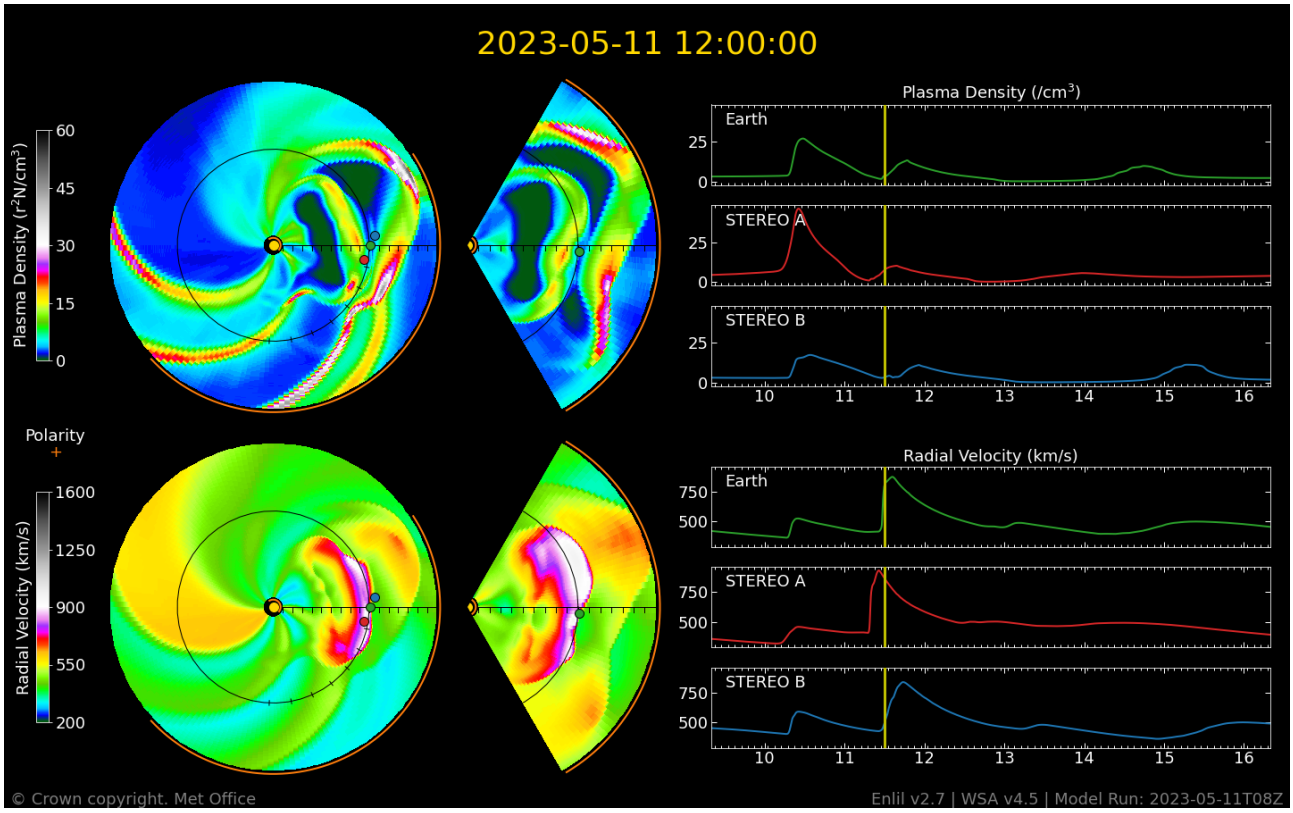

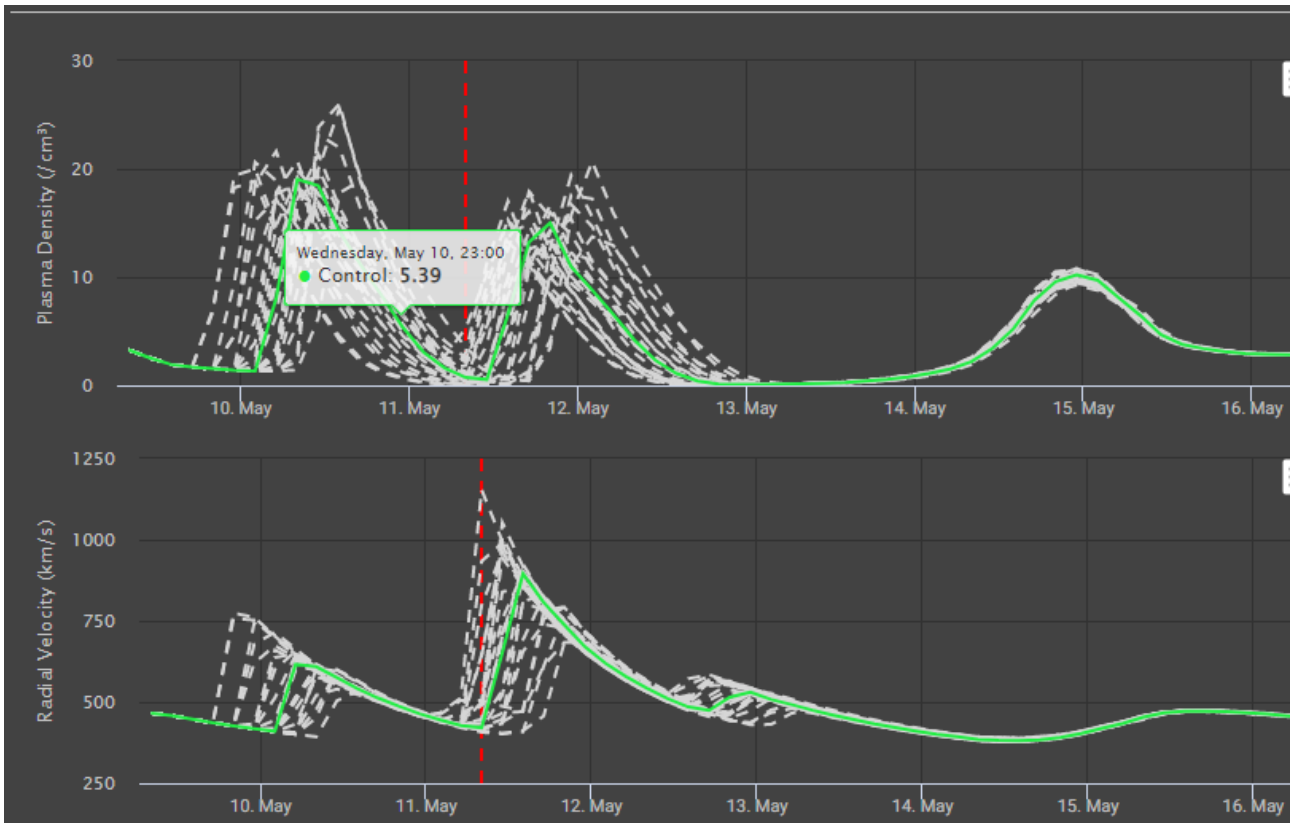

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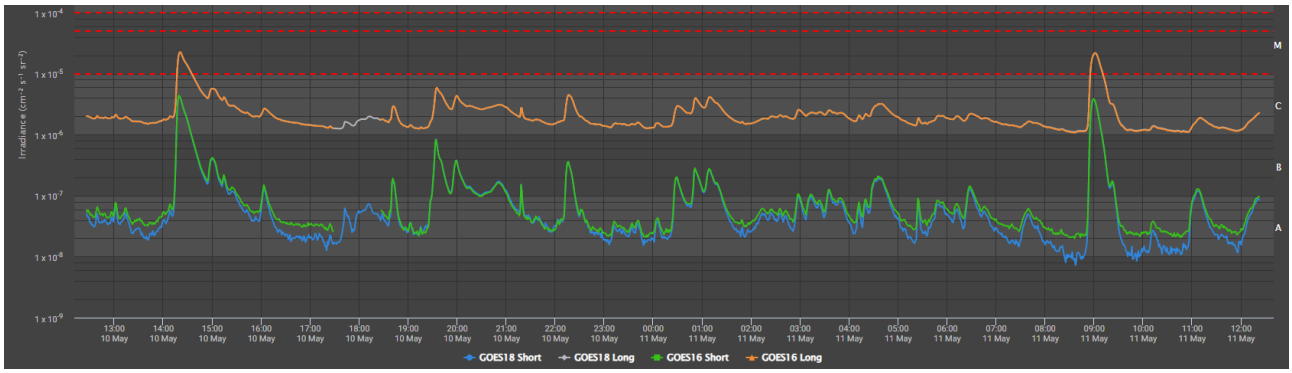
Radio Blackouts - X-Ray Flares:
There are currently nine sunspot regions on the visible disc. AR3296 (Ekc/Beta-Gamma) in the northwest remains the most notable sunspot group although any clear delta spot has now faded in the intermediate portion. The region is now assessed as a Beta-Gamma configuration although changes to classification will become harder to discern in the coming hours and days as it rotates towards the limb. AR3297 (Ekc/Beta-Gamma) is the second largest region on the disc and has shown little change. AR3294 (Cso/Beta) in the west of the disk was the recent source of an impulsive M-class flare despite appearing generally stable, and will perhaps need to be re-assessed regarding the flare risk it presents. Most of the other remaining regions on the disc appear relatively stable. AR3293 has re-emerged to the west of AR3296, although is small and simple, with a currently unnumbered Bxo/Beta region forming to the west of AR3302 and AR3301.

Solar activity is Moderate, with the largest event an M2.2 at 10/1421UTC originating from AR3296 in the northwest quadrant. This region has been the source of multiple M-class flares over recent days, and produced an M4.2 and M5 flares on the 09 May. Further M-class flares are likely, mainly from AR3296 and AR3297, with a slight chance of an X-class flare only slowly decreasing as AR3296 begins to clear around the limb into Day 3.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	50
Very Active	R3 to R5 X Class	No	20	20	15	10

Figure 3: Latest 24hr X-Ray trace from GOES 16.



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux, as observed by GOES16 is currently declining below the S1/Minor Storm threshold following recent flare activity from AR3296 and weak CME influence.

Protons are expected to generally decline back to background through the period, however there remains the chance of further increases above the active threshold if any additional significant flares occur, particularly from AR3296 or AR3297 as they rotate closer to the western limb though tis risk diminishing by Days 3 and 4 (13-14 May) as these spot leave the visible disk. There is also the potential for proton enhancement due to the forecast CME arrival on Day 1 (11 May) though this is lower confidence.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	50	30	20	20
Very Active	**≥ S3 ***	No	5	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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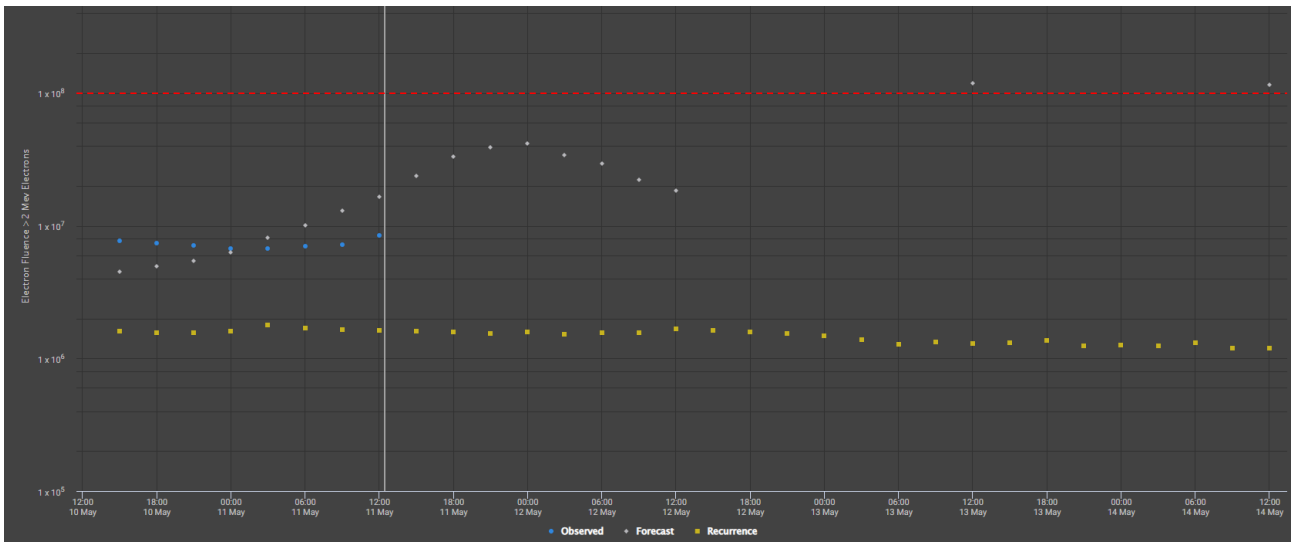
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed by GOES16 is expected to persist at generally background to moderate levels during this period. Electrons should remain suppressed due to the expected arrival of a CME on Day 1 (11 May) with an increasing chance of enhancement into the period as CME effects wane. Electron Fluence is expected to remain below the active threshold to start but with the risk increasing into the period. Current REFM model output viewed as reasonable but lower confidence guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	10	20	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	5

Figure 5: Latest MOSWOC REFM model output.



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